ENERGY AUDIT STUDY

at

INSULEC WIRES
BANGALORE

UNDER
INDIA-EC ENERGY BUS PROGRAMME

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INSULEC WIRES

BANGALORE

ENERGY AUDIT REPORT

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ENERGY AUDIT REPORT

1.0 INTRODUCTION

A comprehensive energy audit study was carried out by a team from TERI, to identify energy saving opportunities in the plant.

During the study, a detailed analysis was made of the major energy consuming plant items/processes, supplemented by measurements of various energy related parameters using appropriate instruments, in order to determine their energy efficiencies and evolve suitable means to minimise wastages.

The recommendations evolved were regularly discussed with senior plant personnel, to identify any practical problems that may arise in their implementation. Several suggestions were promptly implemented, immediately after discussions.

This report presents the findings, recommendations, and the financial implications of implementing these recommendations.

2.0 PLANT DESCRIPTION

The company manufactures copper enamelled wires for electrical industry. Raw material copper wire of large diameter is obtained from outside.

...2/-

The manufacturing activity is divided into three departments. They are :- Wire Drawing, Enamelling and Maintenance.

In the wire drawing department there are 7 automatic machines of different capacities and makes to carry out wire drawing operations. Larger diameter wires are drawn through dies to convert these into smaller diameter wires as per requirements. In case where the reduction is large, the same is carried out in multiple stages.

The wire enamelling department consists of three enamelling ovens. These are continuous operating equipments wherean copper wires are given a coating of enamel by first dipping in enamel solution and then baking it in an oven.

The maintenance department basically consists of a few machine tools like lathes, milling machine, drilling machine, etc., These are used as per requirement for carrying out minor repairs and fabrication for inhouse requirement. The plant also has a diesel generating set of 125 KVA capacity for their captive usage. This is during power shut downs and to augment their power shortages.

The Management of the company are highly conscious of the cost of production of their product. It was observed that the cost of energy is being continuously calculated on day to day basis and closely monitored. Several positive steps have been already taken to reduce the specific energy consumption levels over the years. These have resulted in lowering the specific energy levels and boosted their productivity. Some inhouse engineering of their baking unit have been carried out successfully to reduce heat loss.

PART - II ELECTRICITY UTILISATION

1.0 ELECTRICITY SUPPLY

The main source of electricity is K.E.B. Supply. This supply is received at 11 KV and stepped down to 440V. The Contract Demand is 199 KVA. There is one transformer of capacity 315 KVA 11KV/440V.

Alternate source of supply is a 125 KVA D.G.Set. This is used only when the K.E.B. Supply fails.

2.0 ELECTRICITY CONSUMPTION

The unrestricted Maximum Demand is about 159 KVA. Average Consumption is of the order of 41,050 Kwhrs per month. The average Electricity Bill is about Rs.55,200. The average overall P.F. is maintained at 0.98 to 1.0.

2.1 MAJOR ELECTRICITY CONSUMPTION POINTS

The major Electricity consumption points can be classified as -

- i. Resistance type furnaces/ovens used for Enamelling and Annealing Process. These equipments would be in continuous operation for all the 3 shifts and seven days in a week.
- ii. Electric motors used for drives for various machines including wire drawing, enamelling, etc.,
- iii. Lighting loads

3.0 MEASUREMENTS AND CALCULATIONS

Various Measurements were carried out for the study of Loading Pattern, Load Factor and other Parameters. Sample test measurements using the Power Analyser was done for motors of different capacities. Measured values have been analysed using necessary software and results are tabulated and shown in Annexure - I.

Summary of calculations has been placed in Annexure - II.

4.0 TRANSFORMER LOAD MANAGEMENT

On Analysis of the loading pattern on transformers, it is observed that the load factor works out to 36.5%. The Diversity Factor (based on transformer capacity) works out to 1.98. The utilisation of the transformer is poor. As against an installed capacity of 315 KVA the Maximum Demand is only 159 KVA. It is observed that the loading of the transformer is about 50% only. The loading All day efficiency works out to 97.0% which is poor. The Proposed transformer load management aims at achieving optimum load conditions to minimise the energy losses and improve the All day efficiency. The proposal is discussed in the following paragraph.

4.10 PROPOSAL AND SEQUENCE OF OPERATIONS

4.11 It is proposed to replace the existing 315 KVA Copper wound transformer by a 200 KVA as this would be adequate for the present loading conditions and an additional 41 KVA of peak demand can be safely met.

4.12 It is estimated that there would be a saving of about 5,387 Kwhrs/Yr in Iron losses and 1,470 Kwhrs/Yr in Copper losses. Total savings in Energy Losses would be about 6,857 Kwhrs/yr ie., Rs.8,571/= per year. The all day efficiency works out to 98.3%.

4.13 The additional investment required would be marginal since the returns from the disposal of the existing copper wound transformer would almost offset the cost of new Aluminium wound tranformer.

4.14 In case of expansion programs, if the additional Peak Demand required is more than 41 KVA, (Here the simultaneous additional Maximum Demand is to be carefully evaluated for the entire system including the new loads) then an additional 100 KVA transformer can be added. The lighting loads and loads operating in the 3rd shift only can be connected to this new transformer. Hence with such an arrangement it is is possible to switch off the 200 KVA transformer during the third shift and minimise the energy losses. This scheme also achieves an optimum loading condition on the transformers thereby improving the All day efficiency. Further this arrangement provides an alternate source of transformer so that in ase of failure of one transformer, the other transformer would be available which can be overloaded to certain extent and some of the production units could be run with necessary support from the Diesel Generator.

4.2 TRANSFORMER TAP POSITIONS

It is reported that the transformer tap positions are being operated regularly to maintain required voltage on the secondary side.

5.0 ELECTRIC MOTORS

The Analysis of Performance of Motors has been placed in Annexure - I.

It is observed that though the motors are underloaded under steady conditions, the starting torque requirement is quite high due to the nature of the process especially in case of wire drawing machinery.

5.1 The motors which are operating at a very low P.F. viz., Alind fine wire drawing machine nos.1 and 2, Intermediate wire drawing mahine, UMB fine wire drawing machine should be considered for replacement in a phased manner. It is estimated that a savings in Energy Losses would be about 24,528 Kwhrs/Yr.

5.2 POWER FACTOR

The average Power Factor is maintained at 0.98 laging to 0.19 leading at the substation level. Adequate capacity of capacitors have been provided. It is advisable to avoid the leading Power Factor and maintain the power factor at the optimum level of 0.9 to 1.0. It is advisable to provide capacitors at the motor terminals to minimise the energy losses.

6.0 LIGHTING SYSTEM

Several measures to minimise lighting consumption have already been implemented.

6.1 Task lighting with 36 watts flourscent tube lights have been already provided in enamelling section.

6.2 It is advisable to provide solid state chokes in place of conventional chokes to minimise energy consumption in ballasts.

7.0 RECOMMENDATIONS

7.1 It is recommended to implement the transformer load management as discussed in Section 5.0 to minimise the energy losses and achieve optimum loading of the transformer.

7.2 It is recommended to replace the motors operating at low P.F. (as discussed in Section 7.1) by energy efficient motors in a phased manner.

7.3 It is recommended to replace the conventional chokes by solid state chokes to minimise energy losses in ballasts.

7.4 It is recommended to schedule the operation of BP1 and BP2 machines during 2nd and 3rd shifts to reduce the Maximum Demand as these machines need a heavy starting torque and are operated in an intermittent mode.

8.0 GENERAL OBSERVATIONS

8.1 Circuit Breakers, switches and change over systems are maintained well.

8.2 Most of the House Keeping measures to minimise the energy consumption have already been implemented meticulously.

8.3 The stands which are supposed to carry the charge in the pit furnace (yet to be commissioned), seems to be heavy and it is expected that there would be a considerable heat loss in the furnace due to the heating of stand. It is advisable to get the stand structurally designed to minimise the mass content of iron to reduce the energy losses.

9.0 SUMMARY OF RECOMMENDATIONS AND POTENTIAL SAVINGS

Sl. No.	Proposal	Fuel Type	Estimated Annual Savings		Cost of implementation	Simple Pay-back Period
			Kwhrs/yr	Rs./Yr		
1.	Transformer Load Management	Electy.	6,857	8,571	Marginal	
2.	Replacement of low P.F. Motors by energy efficient Motors		24,528	30,660	To be assessed separately after considering deprn., etc.,	
		TOTAL	31,385	39,231		

PART - II - ENAMELLING PROCESS

1.1 FACILITY DESCRIPTION

There are 3 Baking ovens in this department. The Enamelling operation is carried out continuously in these ovens. The production is carried out in 3 shifts for 7 days a week.

1.2 PROCESS DETAILS

The wires after they are drawn to desired diameters have a lot of stress in them due to inherent nature of drawing operation. These stresses are relieved by passing them through an annealing chamber before they are enamelled. Normally 20 strands of wire are passed in parallel through the oven. The temperature in the annealing chamber is maintained at around 250 to 400°C depending upon the guage of the wire. The wire passes at the speed of 30 to 60 metre per minute depending upon the guage. After passing through annealing zones the wires are dipped in a bath of water to quench the heat. After which it is dipped in a bath of liquid enamell. The copper wires gets coated with enamell. Then the wires are passed through the baking ovens where they are exposed to temperatures of around 400°C. The solvents present in the enamell solution gets liberated and it is exhuasted out of the chamber by means of a exhuast fan. The discharge of the fan is taken outside the building at a height of about 10 metres.Both the baking ovens and annealing chambers have electrical heaters for heating. They are 33 KW and 7 KW capacity respectively. Temperature is controlled by automatic temperature controllers which switch on/off depending upon the measured and set temperatures.

OBSERVATIONS, MEASUREMENTS & ANALYSIS

The oven boxes have been insulated all around with glass wool of about 200 mm thickness on oven no.1 and 2 whereas on an oven 3 ceramic wool has been used. In case of two sides the same are insulated and also has a protective outer sheild of M.S. sheet to protect the electrical heaters. However, it was observed that under the M.S.shields on the top surface of the oven there are M.S.angles running across the length of the oven which have no insulation on top. This has resulted in hih temperatures of angles.

The oven no.3 has the following dimensions: -

The annealing chambers is rectangle in shape and has the following dimensions :-

0.3 x 0.75 x 3.0 metres.

The Baking oven dimensions are :-

0.53 x 1.4 x 3.62 metres.

However in case of oven no.1 and 2 the same is longer by 600 mm.viz., 0.3 x 0.75 x 3.6 metres for annealing chamber and 0.53 x 1.4 x 4.22 metres for baking oven.

1.3 Temperature measurements on the outer surface of the oven were taken for mahcine no.3 by means of a digital temperature guage. These varied a lot due to insulation and non-insulated surfaces. Insulated surfaces were at compartively lower temperatures of 59°C, 65°C, 73°C. However on top of a m.s. angle which was not insulated the same was found to be 90°C. These angles are part of structure and are found to radiate a lot of heat since they are not insulated.

The temperature readings were taken at various points and average temperature worked out to 75^{o}C. The heat loss was calculated and works out to 1720 K.Cal/Hr.

The calculations are given in Annexure - III.

i. HEAT LOSS THROUGH EXHAUST AIR

Velocity of air in the exhaust duct was measured with a pitot tube and water column ` U ´ manometer. The heat loss from the exhuast air is working out to only 78.0 K.Cal/Hour. Detailed calculations are given in annexure - IV.

ii. HEAT LOSS THROUGH TWO OPENINGS

In view of narrow openings and comparatively low temperature of the oven (as compared to high temperature furnaces) the heat loss is very small.

Heat loss through other means, ie., convection through the openings and others may be assumed to be maximum 10% of the heat input.

Now the total heat input = 40 KW

= 40 x 846 K.Cal/Hour

= 33,840 K.Cal/ Hour

And total of all heat losses =

Heat loss by radiation + Heat loss by exhaust air
+ Miscelleneous Losses (10% of input)
= 1720 + 78 + 0.1 (33840)

= 5182 K.Cal/Hour

And the overall efficiency works out to about 84 %.

1.4 Similar calculations for oven No.2 show the heat losses as follows :-

i. Heat loss by radiation : 2003.5 K.Cal/Hour (Annexure - V)

ii. Heat loss in Exhaust air : 161.17 K.Cal/Hour (Annexure - VI)

Taking the other losses as 10% of the heat input ie., 0.1 x 33840 = 3384 K.Cal/Hour

Total Heat Losses = 2003 + 161 + 3384

= 5548 K.Cal/Hour

Or Losses are : 16.4%

Hence Efficiency is approximately : 83.6%

RECOMMENDATIONS

1. To improve the thermal insulation of all three ovens such that after the insulation the surface temperature comes down to maximum 40 ^{o}C. This can be achieved by insulating the top surfaces of channels and angles which are presently bare with either glass wool or mineral wool of about 200 mm thickness. The density of the insulation should be around 150Kg/m3. The insulation material is available in ready to use mattress forms. The heat losses will reduce considerably. The savings works out to nearly Rs. 22,000/= for oven No.3 and Rs.27,000/= for oven No.2, as calculated in Annexure III & V.

2. In order to thermally insulate the oven box from its structural supporting frame, we recommend that all metal to metal contacts between the two should be avoided. This can be achieved by providing asbestos sheet cushions between the two.

3. The oven No.2 has exhaust hood take off point about 450 mm inside from the edge. This results in hotter air being sucked by the exhuast fan. The exhaust hood may be brought forward, similar to the other ovens to prevent hotter air being exhausted and minimise loss of heat.

4. To install highly polished surface inside the oven chamber. This will not absorb much heat and hence will help in conserving energy. Highly polished stainless steel sheets can be used for the purpose.

2.0 DIESEL GENERATOR SET

There is one number diesel power generating set of Kirloskar-Cummins Make, having 125 KVA capacity. However, this is used only periodically whenever there is a power shut down or power cuts.

MEASUREMENTS AND ANALYSIS

Flue gas analysis of the exhaust gases was carried out the combustion efficiency. The results are tabulated below.

FLUE GAS ANALYSIS

Gas Temperature : 428^{o}C

Oxygen Monoxide : 180 ppm

Load : 60 KW

Current : 70 Amps

Volts : 440 V

From the above it appears that the uncombustible levels (CO content) is high. This may call for tuning - up of the diesel engine and proper setting of fuel injection equipment, air system, etc., We recommend you to contact the manufacturers of the D.G.set and compare the above results with their specifications.

ANNEXURE I

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ANALYSIS OF PERFORMANCE OF MOTORS

SLNO	--MOTOR REF-	--H.P.--	MEASUREMENTS						ANALYSIS		
			-HZ-	VOLTS-	AMPS	P.F.	-KVA-	-KWM	UNDER LOAD%	UNDER VOLT%	REMARKS
1	LATHE KIRLOS	3.00	48.10	398.36	3.00	0.31	2.28	0.72	67.71	7	LOW P.F.
2	12" PIPE MIL	35.00	48.10	389.70	68.10	0.58	43.59	25.29	0.00	9	LOW P.F.
3	6"PIPE MILL	35.00	48.20	391.43	48.60	0.44	33.45	14.76	43.46	8	LOW P.F.
4	CIR SAW	12.50	48.20	415.68	7.10	0.11	10.38	1.20	87.12	0	LOW P.F.
5	ID FAN	15.00	48.20	419.14	1.70	0.27	1.29	0.36	96.78	0	LOW P.F.
6	DRY PAN NO 1	35.00	48.30	407.02	80.70	0.18	70.20	13.23	49.32	5	LOW P.F.
7	PUG MILL	50.00	48.10	372.38	57.50	0.47	37.47	17.85	52.14	13	LOW P.F.
8	4" PIPE MILL	50.00	48.20	372.38	35.60	0.79	24.87	19.74	47.07	13	LOW P.F.

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A N N E X U R E - II

SUMMARY OF CALCULATIONS

1.0 SYSTEM PARAMETERS

$$\text{L.F.} = \frac{492610}{159 \times 0.97 \times 8760}$$

$$= 0.365$$

L.L.F. = 0.15 + 0.08

= 0.23

2.0 TRANSFORMER LOAD MANAGEMENT

2.1 ENERGY LOSSES UNDER EXISTING CONDITIONS

Iron Loss = 1.23 x 8760

= 10,775 Kwhrs/Yr

Copper Loss = 2.19 x 8760 x 0.23

= 4,412 Kwhrs/Yr

Total Losses = 15,187 Kwhrs/Yr

All Day Efficiency = 97.0%

2.2 ENERGY LOSSES UNDER PROPOSED CONDITIONS

Iron Loss = 0.615 x 365 x 24

= 5,388 Kwhrs/Yr

Copper Loss = 1.46 x 0.23 x 365 x 24

= 2,942 Kwhrs/Yr

Total Loss = 8,330 Kwhrs/Yr

All Day Efficiency = 98.3%

2.3 NET SAVINGS IN ENERGY LOSSES = 6,857 Kwhrs/Yr

NET SAVINGS IN Rs./Year = 8,571/=

3.0 REPLACEMENT OF LOW FACTOR MOTORS BY ENERGY EFFICIENT MOTORS

Savings in Energy Losses = 0.14 x 30 x 16 x 365

= 24,528 Kwhrs/Yr

Savings in Rs./Year = 30,660/-

ANNEXURE - III

HEAT LOSS BY RADIATION : OVEN NO.3

Total Surface Area

i. Top & Bottom 2 x 1.4 x 3.62 =10.136 m^2

ii 2 Front Sides 2 x 1.4 x 0.53 = 1.484 m2

iii. 2 Sides 2 x 3.62 x 0.53 = 3.837 m2

Less two openings : 2 x 1.05 x 0.1 : 0.21 m2

Total surface area of oven : 15.24 m2

iv. Surface area for Annealing chamber :

2 x 3 x 0.3 = 1.8

+ 2 x 3 x 0.75 = 4.5

Hence total area of oven & annealing chamber :21.54m2

Ambient Temperature : 37^{O}C + 273 = 310^{O}K

Average Surface temperature : 75^{O}C + 273= 348^{O}K

Heat loss by Radiation Q = S. e.A. (Ts4 - Ta4)

Where S = Stefan Boltzmann's Constant

= 4.9 x 10^{-8} K.Cal/m2 OK^{4} Hr

e = emissivity = 0.3, A = Area

Hence $Q = 4.9 \times 10^{-8} \times 0.3 \times 21.54 (348^4 - 310^4)$

= 1719.6 K.Cal/Hour

= 1720 K.Cal/Hour

By better insulation the average surface temp. will come down to 40^oC ($40 + 273^oK$)

Hence Heat loss = $31.66 (3.13^4 - 3.10^4)$

= 31.66 x (95.97 - 92.37)

= 3166 x 3.62

= 114.60 K.Cal/Hour

Hence savings will be : 1720 - 114.6

= 1605.4 K.Cal/Hour or 1.8 KW

Hence Annual savings will be Rs. 22,680.

(Based on 24 Hrs/Day and 350Day/Annum and Rs.1.5/KWH)

A N N E X U R E - IV

HEAT LOSS IN EXHAUST AIR :OVEN NO.3

Velocity in circular duct

$V = C \sqrt{2gcdh}$

Where C = dimension less co-efficient

gc = gravitational constant = 9.81 m/sec2

h = Differential pressure = 0.5 mm of H20

$$= 1 \sqrt{\frac{2 \times 9.81 \times 0.5}{1000}}$$

= 0.099 m /sec

$$\text{Cross section area} = \text{II}/4 \times \frac{(140)^2}{(1000)}$$

= 0.0153 m2

Hence Volume of air = Velocty x Cross Section

= 0.099 x 0.0153

= 0.00151 m3/Sec

= 5.45 m3/hour

Temperature of air : 101°C

= 273 + 101 = 374 °K

Density of air at 374°K = 0.922 Kg/m3

Sp.heat of air at 374°K = 0.241 K.Cal/Kg°C

Heat lost through exhaust air = Volume x density x sp.heat x Delta T

= 5.45 x 0.922 x 0.241 x (101 - 37)
= 77.5 K.Cal/Hour

ANNEXURE: V

HEAT LOSS BY RADIATION : OVEN NO.2

Total Surface Area :

i. Top & Bottom = 2 x 1.4 x 4.22 = 11.816 m2

= 11.816 m2

ii. Sides = 2 x 0.53 x 4.22 = 4.47 m2

= 4.47 m2

iii. Front & back = 2 x 1.4 x 0.53 = 1.484m2

Less openings : 2 x 1.05 x 0.1

= 0.21 m2

Hence total surface area of oven = 17.56 m2

iv. Surface area of annealing chamber

= 2 x 3.6 x 0.3 = 2.16 m2

= 2 x 3.6 x 0.75 = 5.40 m2

Hence total heated area = 25.1 m2

Average surface temperature : 75°C

Ambient temperature : 37°C

Hence Heat lost by Radiation

$Q = 4.9 \times 0.3 \times 25.1 \times \times (3.48^4 - 3.10^4)$

$= 36.89 \times (146.66 - 92.35)$

= 2003.5 K.Cal/Hour

With better insulation the average temperature will come down to : 40^{o}C (40 + 273)

Then the loss will be : $4.9 \times 0.3 \times 25.1 \, (3.13^4 - 3.10^4)$

$= 36.89 \, (95.97 - 92.35)$

$= 36.89 \times 3.62$

= 133.54 K.Cal/Hour

Hence savings will be : 1870 K.Cal/hour

= 2.17 KW

Hence Annual savings will be : Rs.27,342/=

(Based on 24 Hrs / Day and 350 Day/Annum and Rs.1.5/KWH)

ANNEXURE- VI

HEAT LOST IN EXHAUST AIR : OVEN NO. 2

Velocity. $V = \sqrt{2gc \times dh}$

$$V = \sqrt{\frac{2 \times 9.81 \times (3.5 - 2.25)}{1000}}$$

$= 0.156$ m/sec

C/s Area of duct $= 0.0153$ m2

Hence Volume of air = Velocity x c/s Area

$= 0.156 \times 0.0153$

$= 2.39 \times 10^{-3}$ m3/sec

$= 8.6$ m3/Hour

Temperature of exhaust air $= 125\,^{o}C$

Density of air at $125^{o}C$ $= 0.887$ Kg/m3

Sp.Heat at $125\,^{o}C$ $= 0.241$ K.Cal/Hour/$Kg^{o}C$

Hence Heat Lost in exhaust = Volume x density x Sp.heat x dT

$= 8.6 \times 0.887 \times 0.241 \times (125 - 37^{o}C)$

$= 161.17$ K.Cal/Hour